NML
Annual Report
1983-84

NATIONAL METALLURGICAL LABORATORY
JAMSHEDPUR, INDIA

NML ANNUAL REPORT

1983-84

NATIONAL METALLURGICAL LABORATORY
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
JAMSHEDPUR, INDIA

Compiled, Edited & Produced by
J. Goswami

Assistance by
B. V. S. Yedavalli

CONTENTS

FOREWORD

I have great pleasure in presenting the Annual Report of the National Metallurgical Laboratory for the year 1983-84.

This year was a year of considerable R and D activity resulting in more and more utilization of NML developed technology and expertise. For the proposed Paradeep Steel Project in Orissa, evaluation studies of various raw materials particularly the beneficiation and sintering characteristics were completed. Consultancy service was rendered for the establishment of 100 tonnes per day graphite beneficiation plant for M/s Tamil Nadu Minerals. The product value after establishment of the commercial unit is estimated around Rs. 50 millions per year.

Research, Design and Standards Organization, Ministry of Railways, have accepted the electric grade alloy aluminium conductor NML-PM2 for use as enamelled wires in signal relays and have advised their zonal railway workshops to use NML-PM2 wires as substitute to copper wires. The high strength alloy aluminium conductor NML-PM215 is now poised for use as a catenary wire in electrical traction for high voltage overhead transmission lines. South-Central Railway has placed an order for 30 Km length of NML-PM215 catenary wire for trial evaluation.

Sustained creep evaluation work on indigenously produced steels in collaboration with Bharat Heavy Electricals Ltd. (R&D) has contributed to the indigenisation of two grades of boiler quality superheater steels with chromium and molybdenum alloying elements leading to import substitution.

Nickel free creep resistant austenitic steels for automotive exhaust valve applications has been developed. Exhaust valves made from the experimental alloy have been fitted in a diesel locomotive for evaluation trial. Estimation of residual creep life of thermal power plant components on behalf of Thermal Power Stations were determined. Metallurgical examination on failure of thermal power plant components were conducted and remedial measures were suggested to minimise the power outage.

A further quantity of 8 tonnes of sludge containing tin was processed and tin metal was supplied to M/s Tinplate Co. (I) Ltd. Calcium silicide production on pilot scale was successfully developed and production parameters were established for commercialization. The project was sponsored by M/s Ispat Project who are planning to put a commercial plant. Precious metals like nickel, cobalt and copper from polymetallic sea nodules were succesfully extracted with high recovery through hydro-metallurgical techniques.

Consultancy services were provided to M/s Zinc Products, Patna; for putting up 500 tonnes/annum of zinc dust. An agreement has been signed with M/s Tapadia and Co. for establishment of 100 Kg/day electrolytic copper powder plant at Jamshedpur.

Clay graphite stopper heads have been evaluated in the Alloy Steel Plant, Durgapur; for teeming steel ladles of 50 tonnes capacity under CSIR-SAIL Collaboration Project.

'NML-HOPAL' anode for the cathodic protection of the off-shore oil platforms and drilling equipment has been developed. Technology on calorizing of tube materials has been extensively evaluated and its performance under sulphurous atmosphere has been found to be far superior to the carbon steels which are currently used in heat exchanger tubes.

NML in collaboration with Iron and Steel Division of Indian Institute of Metals, organised a highly successful seminar on 'Problems and Prospect of Ferro-Alloy Industry in India' in October 1983. The seminar was inaugurated by Shri N. K. P. Salve, Union Minister for Steel and Mines, and presided over by Mr. R. H Mody, Chairman, Tata Steels.

NML published the second and final volume of the Monograph on 'Indian Ores and Minerals' covering the beneficiation and agglomeration studies on a large number of non-ferous, strategic refractory, non-metallic minerals, coal etc. A new colourful brochure on the R and D activities of National Metallurgical Laboratory is under publication.

The report in different sections furnishes a brief review of the activities and achievements of NML during the period.

V. A. ALTEKAR
Director

Sri T. S. Rajagopal (Insdoc) delivering the welcome address in the Seminar on co-operation in information management (14th & 15th Feb. 1983)

Dr. J. J. Irani, President, Tata Iron & Steel Co., inaugurating the Seminar on co-operation in information management (14th & 15th Feb. 1983)

SPONSORED INVESTIGATIONS CONDUCTED/UNDERWAY

	Title	*Sponsor*
1.	Determination of specific physical characteristics of limestone and dolomite sample.	M/s. Vishakapatnam Steel Project.
2.	Washability studies with coal samples for Jagannath Colliery.	Central Mining, Planning & Design Institute, Ranchi.
3.	Bench scale flotation studies on a sample of coal middlings from Kedio Mines, Seam No. 5.	-do-
4.	Bench scale beneficiation studies on kyanite samples.	M/s. Maharashtra State Mining Corporation.
5.	Beneficiation of low grade kyanite samples from Maharashtra State Mining Corporation.	-do-
6.	Reduction of ash content by froth flotation from the coal middling of Kedla Seam IV.	Central Mining, Planning & Design Institute, Ranchi.
7.	Specified physical tests and determination of free silica content in a raw magnesite sample.	M/s. McNally Bharat Engg. Co. Ltd., Kumardhubi.
8.	Determination of work index of blue dust sample.	M/s. A. S. C. Engineers & Allied Industries, Calcutta.
9.	Evaluation of raw materials from Daitari and Gandhamardan mines for Paradeep Steel Project.	M/s. MECON.
10.	Sintering studies with blue dust sample from Bailadila	M/s. NMDC.
11.	Bench and pilot plant studies on beneficiation of tourmaline rich kyanite sample from Paradi Mines.	M/s. Maharashtra Minerals Corporation.
12.	Reduction of silica content in a manganese ore sample.	M/s. Aditya Mineral Ltd., Nagpur.
13.	Exploratory studies on scheelite sample from Jaketa.	M/s. Utter Pradesh State Mineral Development Corporation.
14.	Beneficiation of low grade graphite sample from Sewadih mines .	M/s. Bihar State Mineral Development Corporation.
15.	Pelletization studies on fine zinc oxide sample.	M/s. F.P.D.I.I., Sindri.
16.	Reduction of iron content mica sample of Calcareous sand.	M/s. A.C.C. Ltd., Bombay.
17.	Treatment of sludge for recovery of tin.	M/s. Tinplate Co. (I) Ltd.
18.	Evaluation of manganese ore containing 50-51% Mn for production of electrolytic manganese dioxide.	M/s. Manganese Ore (India) Ltd.
19.	Production of Calcium-silicide in 500 KVA submerged arc furnace.	M/s. Ispat Project, Calcutta.
20.	Characterisation of imported aluminium alloy Boomerang Garb (for collection of polymetallic nodules from sea bed) for materials specification.	National Institute of Oceanography, Goa.
21.	Metallurgical investigation on the failure of hard drawn grooved copper contact wires.	Research, Design & Standards Organisation, Lucknow Ministry.

	Title	*Sponsor*
22.	Studies on high temperature creep resistance steel	
	(*i*) Super heater tubing steel.	M/s. Bharat Heavy Electrical Ltd.
	(*ii*) Casting & forging steel.	-do-
	(*iii*) Creep tests on 6 samples of Cr-Mo-V steel	-do-
	(*iv*) Stress rupture test on 2 sample of 15 $\times$M steel	-do-
	(*v*) Creep life determination of DVP—9 steel	-do-
	(*vi*) Hot tensile test on 12 sample of $2\frac{1}{4}$ Cr-Mo steel	M/s. A.C.C. Vickers Babcock Ltd., Durgapur.
	(*vii*) Stress rupture and hot tensile tests of HK 40 steel	M/s. Uni Apex Ltd., Bombay.
	(*viii*) Hot tensile test of $2\frac{1}{4}$ Cr-1Mo Steel	M/s. Steel Tube of India, Dewas.
23.	Beneficiation studies of coal sample from Tuticorin	Tamilnadu Electricity Board.
24.	Determination of Bond's work Index of two gold tailing lump sample	M/s. Bharat Gold Mine.
25.	Washing of clay sample	M/s. Bharat Heavy Electrical Ltd., Bangalore.
26.	Physical, Chemical, Minerological & Calcination studies on lime-stone sample	M/s. KIOCL.
27.	Studies on Salem magnesite	Mineral Development Board, New Delhi.
28.	Investigation on iron oxide for its suitability in ferrite manufacture	M/s. Rare Earth India, Bombay.
29.	Quantitative estimation of L-quartz in Coal ash by x-ray diffraction technique	Coal Mining, Planning and Development Institute (CMPDI).
30.	Metallurgical studies on failure of metals and alloys (details furnished in item H under R&D highlights).	

COLLABORATIVE PROJECTS

	Title	*Collaborator*
1.	Characterisation of boiler plates for creep properties	NML-SAIL
2.	Development of steels for cryogenic application	NML-SAIL-MECON.
3.	Improvement in the manufacturing technique for tar bonded basic refractories	NML-SAIL-CFRI.
4.	Evaluation of clay-graphite stopper heads	NML-SAIL.
5.	Evaluation and development of direct reduction processes with iron ore, coal agglomeration	-do-
6.	Evaluation of coal gasification based on direct reduction process	-do-
7.	Evaluation of the use of pre-reduced iron in the L-D conventor	-do-
8.	Suitablity of Indian sea-water magnesia for refractory use	Central Salt & Marine Chemicals Research Institute, Bhavnagar.
9.	Development and performance evaluation of diffusion treated steels in fertilizer and chemical industries	NML-PDIL, Sindri.
10.	Processing of polymetallic sea nodules for extraction and recovery of metallic values	NIO, Goa, IBM, RRLB, NGRI, HCL, HZL.
11.	Analysis of polymetallic sea nodules	-do-
12.	Studies on atmospheric corrosion of metals and alloys under the climatic conditions of India & Japan	International collaborative project with National Research Institute for metals.

UTILISATION OF NML TECHNOLOGY

	Process	*Firm to whom released/being released for utilisation*
1.	Welding filler wires/rods designated NML-PM6 (released for the first time)	M/s. Karnataka Aluminium Ltd., Mysore.
2.	Production of sub-merged arc welding flux	M/s. Weld Flux Engineering, Hyderabad.
3.	Production of extra fine air atomised non-ferrous metal powder	M/s. Jagannath Pyrotechnics P. Ltd., Hyderabad.
4.	Carbon free ferro-alloys by alumino-thermic reaction	M/s. Bharat Pulverising Mills, Bombay.
5.	Production of zinc oxide from zinc waste	M/s. Subhodaya Chemicals, Nellore.
6.	Production of high strength aluminium alloy NML-PM215	M/s. Electrical Mfg. Co. Ltd., Calcutta.
7.	Clay-graphite stopper heads designated 'NML Flovel 35' & 'NML Flovel 50'	Assigned to NRDC for release for the first time.
8.	Production of high strength low alloy structural steel, MA-602	-do-
9.	High current output aluminium base galvanic anode 'NML-Hopal' to cathodically protect steel structures from sea-water corrosion	Being assigned to NRDC for release.
10.	Production of zinc rich primer paint based on alkali silicate	-do-
11.	NML-PM2 Al-Conductor	M/s Rishi Alloys Pvt. Ltd., Muzaffarnagar 250 001.

CONSULTANCY SERVICES RENDERED

	Nature of consultancy	*To Whom Furnished*
1.	Setting up a graphite beneficiation plant for processing of 100 tonnes/graphite ore of Sivaganga deposit	M/s. Tamilnadu Minerals (TAMIN), Madras.
	Stage (*i*) Preparation of detailed project report	Stages (*i*) & (*ii*) completed.
	(*ii*) Assistance & preparation of tender specifications for process machinery, process services	
	(*iii*) Assistance in commissioning of the Plant	
2.	Characterisation of copper ores for quantitative determination of mineral phase for specific utility	M/s. Hindustan Copper Ltd., Malanjkhand.
3.	Know-how for the production of meehanite type of cast iron of different grades	M/s. Usha Telehoist Ltd., Calcutta.
4.	Advisory consultancy for production of distilled zinc dust—implementation of NML process know-how	M/s. Zinc Products & Co., Patna.
5.	Improvement in aluminium utensil manufacture	M/s. Aluminia Udyog, Raipur.
6.	Remedial measures to delay/retained/recurrence of failure of condenser tubes at Renusagar Power Plant	M/s. Hindustan Aluminium Corporation Ltd., Renukoot.
7.	Chandidungri fluorspar beneficiation project (72 tonnes/day treatment plant)	M/s. M.P. & M.M.C.P. Ltd.
8.	Advisory consultancy on reduction of iron contect in a calcareous sand sample for use as raw materiai for production of white cement	M/s. Associate Cement Co. Ltd.

R & D HIGHLIGHTS

A. ORE DRESSING & MINERAL BENEFICIATION

1. Evaluation of Raw Materials from Daitari and Gandhamandan Mines for the proposed Paradeep Steel Project

Beneficiation and detailed sintering investigations have been completed.

2. Sintering Studies with Blue dust samples for Bailadilla

Detailed studies have been completed and report under preparation.

3. Studies on Iron Ore Slime samples

Investigation on fine slime samples have been completed and report prepared.

4. Reduction of silica content in a manganese Ore sample

Bench scale beneficiation studies were carried out on a sample of manganese ore assaying 37.65% Mn, 19.79% SiO_2, 2.80% Fe with a view to lowering the silica content to specified limits. Studies indicated that the silica content could be reduced to about 11.82% SiO_2 by gravity concentration methods.

5. Beneficiation of Wolframite Sample from Gauripur, Bankura District, West Bengal

The sample of wolframite assaying 0.6% WO_3, 7.02% Fe and 85.12% SiO_2 was subjected to hydroclassification and tabling tests at different sizes and the table conc. produced assayed 40.8% WO_3 with 33.6% WO_3 recovery. The loss of WO_3 in the tailing and slimes was very high. The slime has been subjected to hydrocyclone treatments for recovering WO_3 from it. Further tests to improve the grade and recovery are in progress.

6. Bench Scale Beneficiation Studies on Low Grade Kyanite sample from Panajia Mines, Orissa

The sample reported to be reject dumps at the mine site after hand dressing, chipping etc., assayed 39.45% Al_2O_3 with 52.92% SiO_2. Tourmaline and mica were also present in the sample. Studies indicated that the sample could be upgraded to yield a concentrate assaying 51% Al_2O_3 with about 35-38% yield by weight.

7. Beneficiation of Low Grade Graphite sample from Sewadih Mine, Rakha Area, Bihar

Flotation studies have indicated the amenability of the graphite sample to yield concentrates assaying 55% fixed carbon content.

8. Bench and Pilot Plant Studies on Beneficiation of Tourmaline rich Kyanite sample for Pardi Mines

Bench and pilot plant studies on a 4-ton lot of the kyanite sample have shown that kyanite concentrates assaying 63% Al_2O_3 with acceptable limits of tourmaline and mica could be produced by physical beneficiation methods.

9. Pelletization Studies on fine Zinc oxide sample

Exploratory studies have been completed and pellets prepared under different conditions, have been handed over to the sponsors for evaluation.

10. Studies on the Reduction of Iron content in a sample of Calcareous sand

The studies were undertaken with a view to reducing the iron content to below 0.2% Fe_2O_3 in the sand sample (assaying 0.5% Fe_2O_3) for production of white cement.

Sample No. 1

The 5 Kg. sample of the sand (−30 mesh fractions) was studied and the results were found to be very encouraging.

Sample No. 2

A second 200-Kg. lot of the sand sample was studied on a pilot plant scale.

Based on the results obtained, another 100-ton lot of sand sample is to be processed for producing the raw material for production trials in M/s. A.C.C.'s proposed white cement plant.

B. REFRACTORY TECHNOLOGY

1. Improvement on the Manufacturing Technique for Tar Bonded Basic Refractories

With 4 varieties of modified tar supplied by CFRI and with sintered dolomite obtained from Bokaro Steel Plants, several batch composition with tar content from 4 to 7% have been made. Bars of size 6" ×1" ×1" and cylindrical specimens of 5 cm height ×5 cm diameter have been pressed by hydraulic press.

The physical properties like bulk density, cold crushing strength and modulus of rupture have been determined of these pressed sample.

2. Suitability of Indian Sea Water Magnesia for Refractory use

The sea water magnesia prepared by CSMCRI had been dead burnt to a temperature of 1650°C. With this grog, specimens of final brick composition made. The properties like Cold Crushing Strength, bulk density, linear shrinkage, hot modulus of rigidity has been determined. The project is completed and the final report is under preparation. The study reveals that the finished refractory has good room temperature properties but due to higher B_2O_3 content, high temperature properties are not comparable with better grades of imported magnesia.

3. High Alumina Refractories based on Beneficiated Kyanite concentrate and Beach sand sillimanite

Two grades of sillimanite sands from Keral beach were obtained. Determination of other physical properties like sp.gr., sieve analysis, P.C.E. etc. are being carried out.

4. Studies on the Development of High Temperature Castables for 1500-1700°C using fused Alumina as Aggregate and NML made CA cement

The work on the development of high temperature castables suitable for 1500 to 1700°C, using fused alumina aggregate and NML made CA cement has been completed. NML made high alumina castables based on calcium aluminate cement and fused alumina aggregate were developed. The properties of NML made calcium aluminate cement and indigenous fused alumina aggregate was studied. The results indicated that NML made castable compare, very well with the imported castable used for vacuum degassing furnaces. The castable was also tried successfully as high temperature lining material up to 1700°C in gas fired recuperative type of Laboratory Brayshaw furnace.

5. Utilization of Concentrates from Low Grade Magnesia for Refractory purposes

The concentrated Salem magnesite was dead burnt and specimens of final composition were made. These samples were fired at 1600°C and 1700°C. The physical properties showed encouraging results.

6. Studies on the Development and Production of Carbon Bricks and Blocks

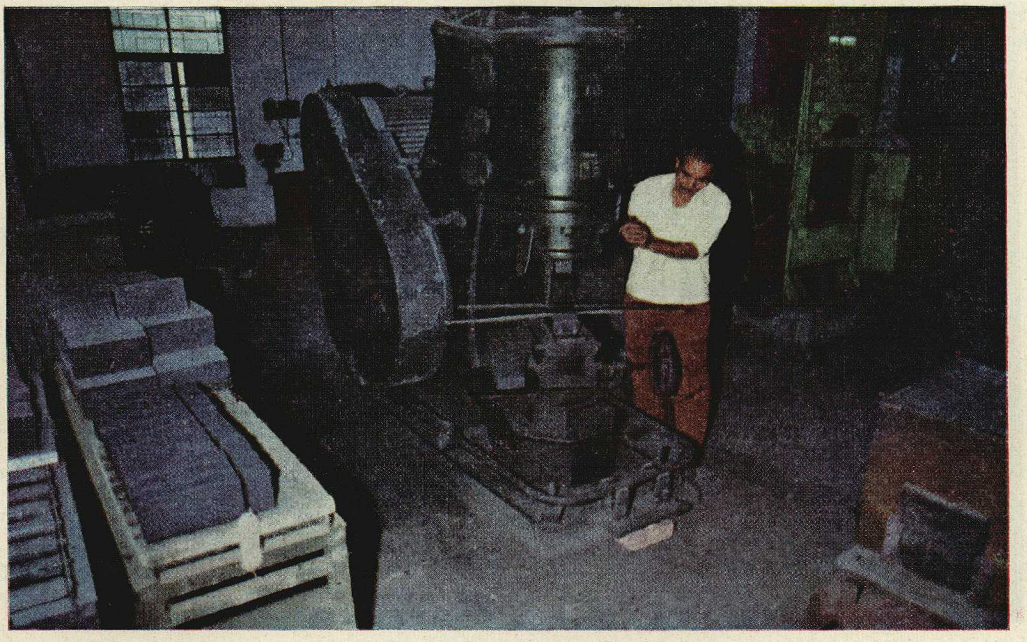
Evaluation of C/H ratio for Bhilai Pitch were completed.

7. Evaluation of clay-Graphite Stopper Heads developed by NML

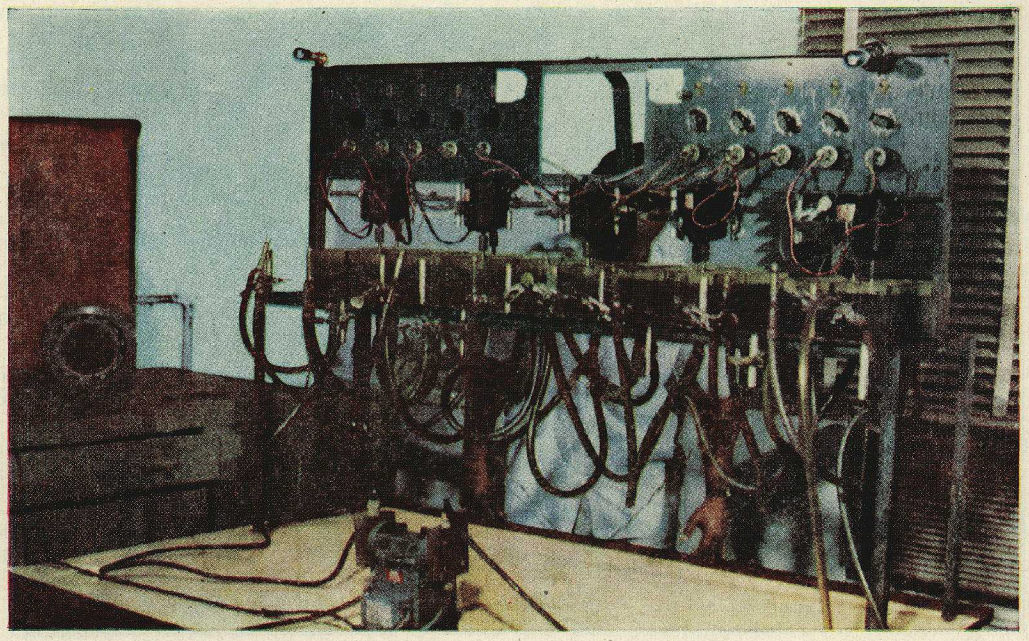
During the period under review 15 no. of clay-graphite stopper heads (pin type) were made and fired under reducing condition. Their physical properties were determined. In-plant trials of these stopper heads are underway at Alloy Steel Plant, Durgapur in a ladle of 10-ton electric arc furnace.

8. Development of Dense High Purity Alumina Grains from Technical Alumina

During the period under review, few more cylindrical buttons were made using NML developed dense high purity alumina grains with the additions of small sintering aids. These samples were fired at 1650°C and their physico-chemical properties determined. The results obtained are encouraging.



Preparation of Dense Carbon aggregate



Solvent extraction of Metals from solutions

C. EXTRACTION & CHEMICAL METALLURGY

1. Production of Calcium-Silicide in a 500 KVA Submerged Arc Furnace

Pilot Plant trial with raw materials supplied by M/s. Ispat Project Limited was undertaken.

2. Treatment of Sludge for Recovery of Tin

A further quantity of 8 tonnes of sludge containing tin was processed and the finished tin was supplied to M/s. Tinplate Co. (I) Ltd.

3. Production of Low-aluminium Ferro-Silicon

Bench scale trials for production of low-aluminium ferro-silicon were successfully completed. Large-scale trials are proposed to be carried out at the VISL, Bhadravati, who have shown keen interest in the purposes.

4. Processing of Poly-metallic sea nodules for Extraction and Recovery of Metallic values

Following two processes were developed on bench scale trials :

(*i*) Reduction roast with fuel oil as reductant followed by ammonia-ammonium carbonate leaching and subsequent solvent extraction, electro-winning of the metallic value.

(*ii*) Direct ammonical leaching in presence of cuprous ion.

5. Electrical Smelting of Dolomite for Extraction of Magnesium.

Execution and installation of the unit is in progress.

6. Production of Electrolytic Manganese Dioxide

Samples of Electrolytic Manganese dioxide produced on titanium anodes with the manganese ore supplied by M/s. Electro-chem (Orissa) Ltd. were sent to National Test House, Alipore, Calcutta and various other battery manufacturers for complete evaluation. The test report received from National Test House clearly indicated that the EMD produced meets the Japanese specification very well in all respects.

7. Production of Activated Manganese Dioxide

Based on the optimum conditions of the various process steps determined earlier, a sample of low ferruginous manganese ore received from M/s. Manganese Ore (India) Ltd., was treated for production of activated manganese dioxide on kg. per batch scale. Samples of activated manganese dioxide produced by the method developed are being sent to various battery manufacturers for evaluation.

8. Production of Pure Magnesium Carbonate from Magnesite by Chemical Methods

Bench scale studies for the production of pure magnesium carbonate from magnesite by atmospheric leaching process were completed. The evaluation studies of the magnesium oxide product for its suitability for use in the basic refractories are being carried out.

9. Anodic Dissolution of Silver in non-Silver Electrolyte—Study of Effects of Electrical and Chemical Parameters on Cathodic Precipitation of Silver

Bench scale studies on the effect of various parameters on the anodic dissolution and cathodic deposition of silver powder with micro fineness and other specific characteristic were completed and the optimum conditions of operation to get satisfactory deposition of silver powder with uniform characteristics were established.

10. Sulphatising Roasting of Sulphide Concentrates

Large scale batch roasting of chalcopyrite concentrates conducted in a modified linder furnace produced 95% copper in water soluble form along with 89% soluble since iron solubility was erratic. Further scale up trials in a direct gas fired furnace is being contemplated.

11. Chloridising and Sulphatisation treatment of Laterite Nickel Ore

Selective chloridisation by using various alkali chlorides to the laterite Ni ore of Sukinda increased the water soluble Ni content to about 88% along with 68% water soluble Cobalt. Sulphation of the sample by using various sulphates and sulphides at 500°C produced about 90% water soluble Ni & 72% soluble cobalt only. Further work is in progress.

12. Production of Metal Powder

a. Distilled Zinc Dust

The NML process know-how was released to M/s. Zinc Products of Patna. A consultancy agreement was signed with this licencee under which services were rendered for implementation of the project at Patna. Most of the equipment is now in place and the plant is being commissioned.

b. Air-atomized Metal Powders

The NML process know-how was licensed to M/s. Jagganath Pyrotechnics Pvt. Limited of Hyderabad to produce up to 2000 tonnes of aluminium powder. A consultancy services agreement is being finalised with this party for assisting them in implementing the project.

c. Water-atomized Metal Powders

Work continued on the development of water-atomized metal powders. Optimal process parameters were determined for the production of water-atomized aluminium powders. Work has been initiated for other water-atomized metal powders such as brass and copper.

d. Micro Bio-hydrometallurgical Metal Powders

Further exploratory work on producing powder metallurgy grade and other metal powders directly from microbial leachates, such as of copper, was conducted. Cemented Powders were produced from microbial leachate supplied by the MACS Research Institute, Pune. These are under testing.

13. Hot dip coating

A consultancy agreement signed with M/s. Modern Malleable Casting Works of Calcutta for development of Alcoat aluminized wires for producing wire-forms.

D. IRON & STEEL TECHNOLOGY

1. Development of Steels for Cryogenic Applications

Six experimental steels with nickel contents of 9% and 5% and with additions of small amounts of vanadium and molybdenum were made. Charpy impact tests carried out on one of the steels, suitably heat treated, showed an impact energy value of 60 J.

2. Structure of Martensites in Cr.Mn.N Austenitic Steels

The Cr.Mn.N austenitic stainless steel specimen have been prepared and examined in transmission electron microscope. The detailed investigation and interpretation is in progress.

3. Wear & Abrasion Resistant Cast Iron Steel Plates

Work has been initiated to get 'NML wearnot' evaluated in the steel plants and their coal washeries through Steel Authority of India Limited (SAIL) for use in main washery pumps, heavy media cyclones and other components.

4. Wear & Abrasion Resistant Steel

Work was undertaken to develope the know-how for rolling of 14% manganese steel into plates. A few plates were successfully rolled from 25 mm thick slabs to 7 mm thick plates at NML. Those were subjected to performance evaluation at TELCO, Jamshedpur, along with cast 14% manganese steel plates in the steel blasting machine chamber. Rolled plates were reported to have exhibited better work hardening property and lower weight loss as compared to cast manganese steel plates.

E. ALUMINIUM TECHNOLOGY

1. Product Development from High Strength Aluminium Alloy Conductor, Designated NML-PM215

South-Central Railway has placed an order for supply of 30 Km. length of NML-PM215 catenary wire for trial evaluation near Vijawada. The processing of the conductor will be done at M/s. Electrical Manufacturing Co., Calcutta. The technology of production of NML-PM215 wire rod is at the stage of transfer to EMC, Calcutta.

CBIP has approved the use of All Aluminium Alloy Conductor (AAAC) made from NML-PM215 for overhead transmission in coastal/polluted area of Gujarat, Kerala, Karnataka and Tamil Nadu by their respective State Electricity Boards. Initially 100 Km. each will be installed for evaluation.

Creep test of NML-PM215 catenary wire at ambient temperature ($35 \pm 5°C$) as per Railway specification has been carried out.

Fatigue test of NML-PM215 catenary wire was carried out in vibrophore fatigue testing machine at Civil Aviation Department, New Delhi at various stress levels. Fractographic studies by scanning electron microscope on the fatigue failed samples of the catenary wire were carried out.

2. Studies on Corrosion Behaviour of Aluminium Alloy Conductors-NML-PM215

Salt spray tests of the individual strands of the catenary wire made from NML-PM215 aluminium alloy and D50S have been carried out as per Railway specification. It was observed that NML-PM215 catenary wire possesses superior corrosion resistance to that of D50S conductor. Studies on polarization behaviour of NML-PM215 catenary wire in acidic and alkaline media were completed.

3. Non-corrosive, Non-polluting Degassing of Aluminium

To standardise the filtration unit fabricated for continuous degassing and filtration, few heats of commercial grade aluminium were made. The molten metal was degassed by nitrogen and filtered through a bed of 12" height of NML-Reactive filter. Hydrogen analysis of the sample showed effective degassing. Further work on the filtration through a larger chamber containing 20" filter bed is under process to simulate the industrial conditions.

4. Friction and Wear Characteristics of Aluminium Alloys

The wear characteristics of three alloys containing Pb were determined. Preliminary results suggest that wear properties of the alloys may be related to the lead content. Further work is on progress.

F. MAGNETIC MATERIALS

1. Effect of Alloying Additions on the Stability and Magnetic Properties of Mn-Al-C Alloys

The mechanism of 'tao' phase (fct) formation on Mn-Al-C alloys was studied by X-ray diffraction and optical microscopy. Electron microscopy studies are being taken up to understand further the mechanism of the 'tao' & phase formation.

2. Low Cobalt Magnetic Alloys

With a view to developing good permanent magnets from Fe-Cr-Co alloys containing low cobalt a few heats were made. Hot forging, hot rolling, cold rolling/wire drawing and heat treatment (deformation aging) are being carried out.

3. Soft Magnetic Fe-Al Alloys

Work was initiated for developing high permeability Fe-Al alloys as substitute for some Ni-Fe alloys. A few heats of Fe-Al alloys were made and work on hot forging, hot rolling, cold rolling and heat treatment are being taken up to be followed by proper magnetic evaluation.

G. HIGH TEMPERATURE CREEP RESISTANT STEELS

1. Studies on High Temperature Creep Resistant Steels

a. Super heater Tubing Steels

The following grades of steels for superheater tubing application in Boiler is under creep evaluation:

	Steel grade	*No. of casts*	*Producer*	
1.	$2\frac{1}{4}$Cr-1Mo Steel (ASTM 213-T22)	6	MUSCO ASP	3 casts 3 casts
2.	$1\frac{1}{4}$Cr-$\frac{1}{2}$Mo Steel (ASTM 213-T11)	6	MUSCO ASP	3 casts 3 casts
3.	1Cr-$\frac{1}{2}$Mo Steel	2	VISL	

10,000 h data on $2\frac{1}{4}$Cr-1Mo steel as required for acceptance purpose by Central Boiler Board have been generated and the final report will be submitted shortly. 33,000 h tests on all the 6 casts of T22 grades are also nearly completed.

b. Casting and Forging Steel

The following grades of steel produced by CFFP were evaluated for creep properties for various durations extending up to 40,000 hours.

1. $\frac{1}{2}$Cr-$\frac{1}{2}$Mo (0.5 FO) Steel
2. GS 22 MO Steel
3. 18 Cr-Mo910 Steel
4. Ti-B Bolting Steel
5. 15$\times$M Grade

3. Development of Nickel-Free Creep Resistant Austenitic Steels

The exhaust valves conforming to Tata D1 engine as well as DLW engines (WDM2) were manufactured from two semi-commercial heats each weighing 100 kgs. The valves were sent to Diesel Locomotive Works, Varanasi for evaluation in their Loco engines.

4. Estimation of Residual Creep Life of Thermal Power Plant Components

The following samples were received from various thermal power plants for the estimation of residual creep life:

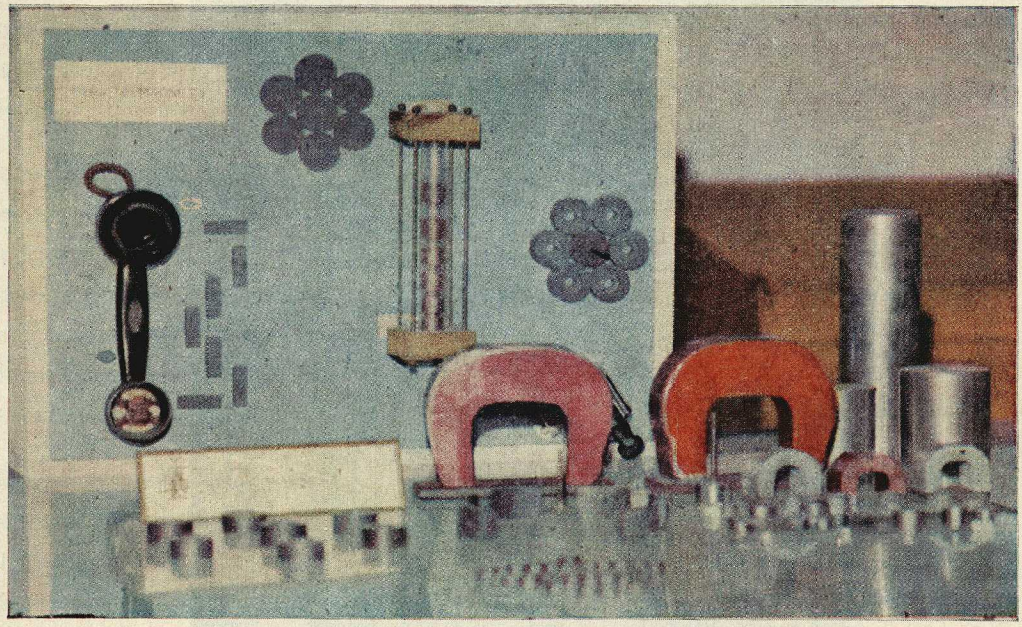
(*i*) Main Steam pipe of Boiler No. 2 & 3 with service life of 100,000 h Neyveli Lignite Corporation.
(*ii*) Superheater tubes which has rendered service for 100,000 h Indian Oil Corpn., Gauhati.
(*iii*) Superheater tubes of Unit No. 5 (50 MW) from Barauni Thermal Power Station, Bihar State Electricity Board. The work on above samples is completed and the investigation report submitted.

The residual life estimation on the following samples is in progress:
Furnace tube which has rendered a service life of 70,000 h Indian Oil Corporation, Haldia.

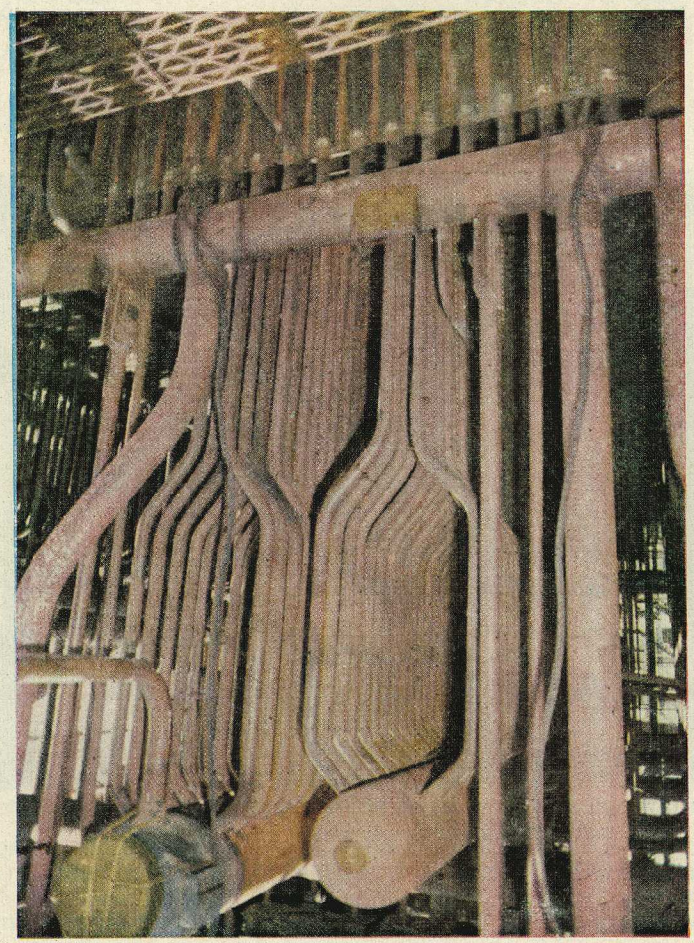
5. Steels for Short-term Evaluation

During the period the following samples were received from different organisations for determining the specific properties:

	Material	*Nature of investigation*	*Sponsor*	*Status*
(*a*)	$2\frac{1}{4}$ Cr-1 Mo Steel	Hot tensile tests on 12 Nos. of sample	M/s. ACC Vickers Babcock Ltd., Durgapur	Test completed and the report submitted
(*b*)	HK40 Steel	Stress-rupture & Hot tensile test	M/s. Uni Apex Ltd. Thane, Bombay	-do-
(*c*)	$2\frac{1}{4}$ Cr-1 Mo Steel	Hot tensile test	M/s. Steel Tubes of India, Dewas	-do-
(*d*)	Cr-Mo-V Steel	Creep tests on 6 Nos. of sample	BHEL (R&D), Hyderabad	Tests in progress
(*e*)	15$\times$M Steel	Stress-rupture tests on 2 Nos. of sample	-do-	-do-
(*f*)	DVP-9 Steel	Creep life determination	-do-	-do-



Magnetic materials developed at NML



Network of tubes in a modern boiler where even a small leakage causes outages in power generation

H. METALLURGICAL INVESTIGATION STUDIES ON FAILURE OF METALS & ALLOYS

A. Investigations Completed

Sl. No.	*Nature of investigation*	*Sponsored by*
1.	Failure of Condenser Tubes at Renusagar Power Plant	Hindalco, Renukoot
2.	Failure of Boiler tubes of BTPS Unit No. IV	Badarpur Thermal Power Station
3.	Failure of I.D. Fan Blade	Sangrante Super Thermal Power Station
4.	Failure of Boiler Tubes B1 & B2	Badarpur Thermal Power Station
5.	Failure of Economizer Tube at the Weld Joint	Ehove Thermal Power Station
6.	Failure of Water Wall Tube	Badarpur Thermal Power Station
7.	Metallographic Examination of Welded Superheater tubes (1 Cr-$\frac{1}{2}$ Mo)	Bokaro Thermal Power Station, D.V.C.
8.	Failure of Water Wall Tubes A & B	Badarpur Thermal Power Station
9.	Failure of Heater Coil of Synthesis Plant	Hindustan Fertilizer Corpn. Ltd., Haldia
10.	Failure of Superheater & Platen Super Heater Tubes (SIII & SIV)	Ehove Thermal Power Station
11.	Failure of Stainless Steel Slab during Rolling	Ashoka Alloys Ltd., Ambala
12.	Metallographic Analysis of Eroded Steel Plates	CFRI, Dhanbad
13.	Failure of Platen Superheater Tubes No. 1 & 3 of Unit No. 6	Obra Thermal Power Station
14.	Failure of Superheater Tube (MR9593) and Water Wall Tube (MR 9594)	Maharashtra State Electricity Board
15.	Failure of Waterwall Tubes No. 4 & 5	Ukai Thermal Power Station
16.	Failure of Reheater Tubes 12/3 & 13/3	Ukai Thermal Power Station
17.	Metallurgical Evaluation of Beater A & B used for Coal Mill	HFC Ltd., Barauni
18.	Failure of Waterwall Tube	Bokaro Thermal Power Station
19.	Failure of Stainless Steel Catenary Wire for 25 KV Traction Tensioning of Indian Rlys.	RDSO, Lucknow

B. Advisory Consultancy Completed

1.	Remedial Measures to Prevent/Minimise Corrosion of Condenser Tubes at Renusagar Power Plant	Hindalco, Renukoot

C. Investigation in Progress

1.	Failure of Boiler Tubes in Kerosene treating Units	Bongaigaon Refinery & Petrochemicals Limited, Assam
2.	Failure of Turbine Bucket used in Diesel Engines	Diesel Locomotive Works, Varanasi, Indian Rly.
3.	Failure of Boiler Tubes	Chandrapura Thermal Power Station
4.	Metallurgical Evaluation of Boiler Plates	Assam Saw Mills
5.	Metallurgical Evaluation of Boiler Plate	Woodcraft, Assam
6.	Failure of Superheater, Reheater & Water Wall tubes	Chandrapura Thermal Power Station
7.	Failure of Nozzle at high temperature	-do-
8.	Failure of Boiler Tubes	Ennore Thermal Power Station

I. MECHANICAL WORKING & TESTING

1. Stainless Steel clad Aluminium sheet

A novel technically viable process has been developed for the production of ductile stainless steel clad aluminium sheet by roll-bonding technique. The necessary parameters of the process have been studied and standardised. The process has been patented.

2. Aluminium-mild steel-aluminium sandwitch composite

Exploratory work on the hot roll-bonding of aluminium-mild steel-aluminium was carried out for the economic production of the composite sheet for various structural uses. Satisfactory results were obtained. Further work is in progress.

3. Copper clad Mild Steel wire

Explosively cladded copper over mild steel billets was hot rolled to rods and the weld joining parameters of the hot rolled rods were studied, so as to develop a process for producing continuous length of the cladded rod from explosively produced billete.

4. Development of Silver-Cadmium Alloy Contact Material

Work on contact materials containing 15% cadmium oxide in silver is being continued. To standardise various parameters with special reference to internal oxidation characteristic, several heats of silver and cadmium were made and are under study. Further the process for making silver/silver cadmium composite has been developed and standarised.

5. Development of Silver base Contact Materials by Powder Metallurgy Technique

Work on Ag-10 W contact material has been completed. The various parameters involved in the production of the contacts have been standardized. Initial work on silver base content with higher amount of tungsten material is in progress.

6. Development of Silver-Cadmium Oxide Contact Materials

Work on contact materials containing 10% cadmium oxide in silver have been completed. Test samples were made out of this alloy involving making of the sized contact, brazing of the contact to the base material and electroplating of the assembly. These assemblies were then supplied to Indian Railways for service performance.

7. Development of Silver Brazing Alloy

Several heats of brazing alloy containing silver, copper, cadmium and zinc were made. The cast slabs were subjected to heat-treatment prior to rolling. The slabs were then reduced to different thickness as per standard specification.

8. Development of Nichrome Alloys

Development work on 35 Nickel — 20 Cr and balance iron has been started. Few heats were made in high frequency furnace. Mechanical processing of the ingots are in progress.

9. Mechanical Testing and working facilities

Mechanical testing and working such as tensile, compression, durability, torsion, hardness, impact, wear and fatigue, rolling, forging, extrusion, wire drawing were carried out for the Laboratory's R&D projects and for various industrial organisations for the sponsored work.

J. FOUNDRY TECHNOLOGY

1. Product Substitution with NML Pyroloy 1000

Ten heat of 9 per cent aluminium cast iron were made in 25 kg arc furnace at fixed percentages of carbon and silicon but with minor additions of other alloying elements like nickel and copper as the strength of the cast was very low. The minor additions were made with a view to improving the stength of the alloy and at the same time to develop an improved structure. The melts were cast into standard tensile test specimens and bar moulds for subsequent tests.

2. Sodium Silicate Bonded Sand System

To get rid of the adverse effect of humidity on hardening of sodium silicate bonded sand system, work is being carried out to develop a suitable technique of ramming the sand mixture over heated patterns with satisfactory moulding properties.

3. Compacted Graphite Iron

Two composition of master alloys of the inoculants to be used in the developmental work on compacted graphite iron were made. A few heats were made to produce compacted graphite using these inoculants. The mechanical properties and microstructure study is being carried.

4. Preparation of Silica Sol

Efforts are being made to prepare silica sol from certain silica bearing inorganic compounds and to enrich the silica content of silica sol so produced. Determination of pH and silica were made. The results obtained so far are encourging.

K. CORROSION STUDIES ON METALS & ALLOYS

1. Development of High out-put Non-Pollutant Aluminium base Sacrificial Anode for Cathodic Protection (NML-HOPAL)

NML-HOPAL ANODE for the cathodic protection of the off-shore oil platforms and drilling equipment has been developed. The anode material has driving potential of 1.2 V.S.C.E. and life of 2860 amp hr per kg with current efficiency of 96%.

Efforts are now being made for large scale evaluation trial under the actual service conditions.

2. Development of Sintered Magnetite Anode for Cathodic Protection

Compatibility of the binding material including composition, mesh size, etc. with the magnetite to produce normal size insoluble anode are being studied.

3. Studies on Corrosion of Metals in Non-aqueous Solvents

Polarisation and passivation of Fe & Ni in organic solvents containing traces of moisture and chloride ions were studied. Interesting results on inhibitive effect of moisture have been obtained.

4. Studies on Stress Corrosion Cracking of Metals

Hydrogen embrittlement studies of cold drawn wires of low carbon and low alloy steels were made under various applied stresses to measure time to fracture. Effect of dynamic tensile loading on the slow strain rate hydrogen embrittlement are being studied. The discontinuity of the potentials during the test suggests that hydrogen has marked influence on the medeation of instability band (Luder's Band) on the specimen surface.

L. SURFACE COATING ON METALS

1. Development and Performance Evaluation of Diffusion Treated Steels in Fertiliser and Chemical Industry

The evaluation of calorized M.S. coupons was carried at PDIL Sindri for 52 hours under conditions of high temperature and sulphurdioxide atmosphere. The corrosion losses reported on coupons are as under:

Carbon Steel	— 730 mdd
ADTS-2 (NML)	— Nil
ADTS-3 (NML)	— Nil

Further work on in situ evaluation under plant conditions and laboratory hot corrosion tests are under progress.

2. NML Pigmented Primers for Corrosion Protection of Steel

A number of compositions were made and evaluated electro-chemically. Further work is in progress.

3. Conserving Energy—Nickel Deposition by A.C. Potential

Experiments conducted so far indicated that it is possible to conserve energy by superimposition of AC in electroless nickel plating and obtain satisfactory deposits.

Further work is in progress regarding rate of deposition, phosphorous content and structure etc. of the coating.

4. Acid Zinc Plating of Strips

Preliminary experiments were conducted to find the suitability of acid zinc plating of steel strips in a continuous line.

5. Electrolytic Nickel Powder

Preliminary experiments were conducted to obtain nickel powder from ammonical and acid baths on bench scale. Further work is under progress.

M. STANDARD REFERENCE MATERIAL & ANALYTICAL WORK

1. Preparation of standard refernce materials

Standardisation of manganese ore and ferro-vanadium are being finalised in addition to replinshment of 0.4% carbon steel.

2. Analytical Work

(*i*) Chemical Analysis—2807 samples were analysed for 9305 radicals.
(*ii*) Spectrographic Analysis—92 samples were completely analysed
(*iii*) X-ray fluorescence spectrometry—912 samples were analysed for 2048 radicals.
(*iv*) Analysis of Gases on Metals—48 samples were analysed for 133 radicals.

N. APPLIED BASIC PROJECTS

1. Fracture Studies in Mg-Al-Zn Alloys

Mg-Al-Zn alloys containing Li were made in plate and cylindrical moulds. The alloys were homogenised at 450°C and rolled for the determination of mechanical properties. Their fracture behaviour was also studied in three point bend test in a hounsfield tensometer. The fracture morphologies were studied through scanning electron microscope and compared with those of high strength Al alloys. Distinct differences in the nature of fracture could be observed. Whereas morphology of fracture in Mg alloys showed elongated dimples with crack propagating through microvoid coalescence ahead of the crack tip, cracks in high strength Al alloys propagated along the grain boundaries by crack tip opening.

2. Solidification Structure of Al-Cu Alloys

Grain size measurements in the alloys of various compositions were carried out by Intercept method. The data on grain size versus dendrite spacings of the secondary arms and grain size versus compositions also dendrite spacing versus composition and solidification rates were analysed and the correlationships were found.

3. Grain Refinement of Wrought Aluminium Alloys

In Al-6% Cu alloy grain size of 12-15 could be achieved. The grain size was not found stable at high temperatures, with the result only extended plasticity, about 25% elongation, could be achieved.

4. Splat Cooling of Aluminium Alloys involving a monotectic reaction

A few ternary alloys containing Pb have been splat cooled to retain Pb in a supersaturated solid solution. Further work is in progress.

5. Studies on Corrosion Inhibition Mechanism using Radio Active Trace Technique.

Using Cr^{51}, a very sensitive technique had been developed to determine Cr pick-up and open circuit potential variations in an aqueous solution containing an inhibitor. The effect of concentration, temperature, pH of solutions, presence of other passivating ions etc. have been studied. Based on this, a low chromate based corrosion inhibitor has been developed which gives high inhibition efficiency and has been found to protect mild steel, galvanised steel, aluminised steel, copper, brass, aluminium (35), lead, solder alloys in presence of Cl^- and SO_4—S_{04-} _under static conditions. Trials are underway for testing this inhibitor under dynamic conditions.

EXTENSION UNIT

NML UNIT IN CSIR COMPLEX

The NML Madras Centre during the period under review was engaged in applied and fundamental R&D projects in various disciplines, apart from rendering technical services to various public and private sector organisations. Several important sponsored investigations have been successfully completed viz. bench scale beneficiation studies on coal samples from Tuticorin Thermal Power Station, Tamilnadu, Calcination studies on limestone sample from MECON, washing studies on clay sample from BHEL, Bangalore etc. At the instance of Mineral Development Board, New Delhi, NML Madras Centre has taken up detailed studies on Salem Magnesite to evolve a flowsheet for the recovery of magnesite values. NML Madras Centre has undertaken chemical analysis, metallorgraphic and mineralogical studies on various samples received from outside parties as also for its own R&D programmes. Exposure studies on samples received from Japan under the project of NML-NRIM collaboration on atmospheric corrosion has been completed and the results are being evaluated.

A brief review of various projects and activities is furnished below:

1. Beneficiation Studies on Coal samples from Tuticorin Thermal Power Station, Tamilnadu

Studies were conducted on high ash coal from TTPS for reduction of their ash content at the instance of Tamilnadu Electricity Board. The samples, one lumpy and the other pulverised (feed to boilers), assayed 45.9% and 45.7% ash respectively. Exhaustive flotation studies conducted on the samples established that grinding of the sample followed by rougher flotation and 2 cleaner flotations of the rougher concentrate would yield a final concentrate assaying 19.7% ash with a fixed carbon recovery of 85.7% in it.

2. Determination of Bond's Work Index of Two Gold Tailing Dump samples from M/s. Bharat Gold Mines Ltd.

At the instance of M/s. Bharat Gold Mines Ltd., Kolar and MECON, Bangalore; work indices of two gold tailing samples viz., (1) current tailing dump samples and (2) old tailing dump sample were determined.

3. Washing of a Clay sample from BHEL

A sample of clay from Bageshpur was received from BHEL, Bangalore to reduce its Fe_2O_3 content to below 1% to make it suitable for the manufacture of electroporcelains. Scrubbing the sample with 0.6 kg/tonne of Na_2CO_3 followed hydroclassification and subsequent treatment of the classifier overflow with 1.5 kg/t of sodium bisulphite yielded a product analysing 0.91% Fe_2O_3 with a recovery of 91%.

4. Physical, Chemical, Mineralogical and Calcination Studies on Limestone sample from M/s. KIOCH

A sample of limestone was investigated for its suitability for producing lime for use as flux/binder in the production of iron ore pellets. The calcination tests were performed in an oil fired furnace as per Rumanian specifications and the lime produced was tested for its hydration and other properties as per Rumanian standards. The sample was found to be suitable for use in vertical shaft kilns for lime manufacture.

5. Studies on Magnesite from Salem

The work was taken up at the instance of the Mineral Development Board, with a view to evolving a flow sheet for the optimum recovery of magnesite values from the magnesite deposits of Salem.

About 55 tonnes of the ROM ore and 5 tonnes of magnesite dumps have been received and the preliminary work has commenced.

6. Studies on Atmospheric Corrosion—NML & NRIM, Japan, Collaboration

The studies on the samples received from Japan were completed.

7. Electroflotation of Fines

An electroflotation cell (1 kg capacity) was designed and fabricated to study the flotation characteristics of different mineral fines. In the preliminary flotation studies, Chitradurga chalcopyrite concentrate and Salem magnesite concentrate were used to optimise the condition for good floatability.

8. Streaming Potential Measurement

To understand the mineral-collector interactions through zeta potential measurements, a streaming potential determination apparatus was designed and fabricated out of glass. The apparatus is being standardised.

9. Studies on Silica Sand

Work was initiated to use flotation technique for the removal of Fe_2O_3 and TiO_2 from sand. The results of flotation are encouraging. Further work is in progress.

10. Sand Testing, Heat Treatment, Metallographic Studies, Mineralogical Studies, Analysis etc.

The Unit conducted the above work on behalf of various industrial concerns and organisations. A number of sand samples were evaluated for their suitability for foundry purposes. 10 samples of steel and aluminium alloys were tested for tensile strength and elongation.

During the period 117 testing and investigations were conducted in the area of metallography, failure studies, heat treatment and hardness measurements on behalf of various organisation. About 100 thermo-couples were tested for their accuracy. 26 refractory samples were tested for various properties including thermal conductivity. Mineralogical studies were carried out on all universal processing investigation. 505 samples were analysed for 2102 radicals for various industries and units on R&D work.

FIELD STATIONS

NML FIELD STATIONS AT HOWRAH, BATALA & AHMEDABAD

During the period the Field Stations had rendered technical services to the engineering, foundry industries and particularly the small scale industries.

These services comprised of chemical analysis (both qualitative and quantitative) of various metals alloys and minerals, mechanical testing of metals and alloys, testing of foundry moulding sands and bonding clay, on the spot study of foundry production problems and their remedial measures, improvement in the product quality according to the stringent specification and export purposes.

Work done by the three field stations during the period is furnished below:

	Howrah	*Batala*	*Ahmedabad*
I. Chem. Analysis:			
(*a*) No. of samples	631	105	800
(*b*) No. of radicals	2396	383	2835
II. Mech. Testing:			
(*a*) No. of samples	347	2	—
(*b*) No. of tests	347	2	—
III. No. of Tech. Enquiries	23	183	92
IV. No. of foundry visits	10	152	3

Howrah Field Station had also conducted tests on Seventeen metallography samples. The Ahmedabad Field Station had conducted beneficiation studies on one bauxite sample.

112 students of the Ramkrishna Silpa Mandir, Belur, were given practical training on foundry technology related to mechanical testing, sand testing and metallography testing at the Howrah Field Station.

ENGINEERING SERVICES

ELECTRONICS ENGINEERING

A. INSTRUMENTATION

(*i*) *Corrosion*

Design of a corrosion meter has been completed. Procurement of electronic components for this instrument is under progress.

(*ii*) *Refractories & Ore-dressing*

Two Netz DTA/TG apparatus has been installed and commissioned.

(*iii*) *Planning of Microprocessor Lab. is under progress*

ELECTRICAL ENGINEERING

A. DEVELOPMENT WORK

(*i*) *Development of Arc-Plasma Technique for use in Metallurgical Processes.*

A 100 KVA arc—plasma furnace was fabricated, installed and commissioned. Studies were conducted on various parameters such as configuration of electrodes, material charging system, voltage and current etc. Argon and nitrogen were used as plasma forming gases. Successful melting of kyanite, pure alumina and magnesite were carried out.

(*ii*) *Design and fabrication of 3-Zone Isothermal Electric Resistance Furnaces for Creep Testing Machines*

Three furnaces were fabricated and installed for testing their performance in long service.

B. DESIGN OF POWER DISTRIBUTION SYSTEMS, TEMPERATURE AND HUMIDITY CONTROL SYSTEM INSTALLATION & COMMISSIONING

Design of power distribution systems, temperature and humidity control systems, in respect of following major jobs were carried out. Their detailed specifications and layouts were prepared. Installation and commissioning of engineering projects were planned and executed.

(*i*) Supply and installation of distribution panel with multitier units, totally enclosed type, in Creep building Sub-Station.

(*ii*) Laying and finishing of various capacity cables in Creep Laboratory.

(*iii*) Replacement of unserviceable power supply system for Tie-line from MBPP to FPTD.

(*iv*) Electrical services for the construction of Programming Wing.

(*v*) Electrical services for the modification of old Auditorium.

(*vi*) Power supply to various new equipment in the Laboratory and its large scale facilities.

(*vii*) Replacement of unserviceable power systems in the Laboratory and its large scale facilities.

C. PREVENTIVE MAINTENANCE AND BREAK-DOWN REPAIRS

Scheduled preventive maintenance and replacements, planning and execution of proper inspection and monitoring of various critical components while in service and fault sorting and repairing were carried out for the electrical equipment, of the laboratory, its pilot plants and residential areas; comprising of high tension sub-stations, electric arc furnaces, high frequency furnaces, resistance furnaces, rectifiers, electric motors and their control centres, temperature and humidity control equipment etc.

D. FORECASTING AND PROCUREMENT OF SPARE PARTS

Forecasting and procurement of spare parts for power distribution system, temperature and humidity control system, melting facilities, metal testing control system, pilot plants etc. were carried out.

CIVIL ENGINEERING

WORK COMPLETED

1. Extension of eastern wing of NML building at 2nd floor of NML.
2. Re-roofing of the stores shed at pilot plant site.
3. Repair of roof area and floor of cycle stand, NML.
4. Providing, repairing and replacement of false ceiling in the residential quarters of Director.
5. Installation of diesel engine pump set at Agrico Flats.
6. Replacement of corroded black sheet roof in NML building premises housing of State Bank of India.
7. Construction of toilet block at 2nd floor of eastern wing at NML.
8. Repair of damaged sewer line.
9. Waterproofing treatment against the leaking roof of the residential quarters.
10. Laying of pipeline for water supply to the MS Flats at Agrico.
11. Installation of powder injection dispenser at FPTD.
12. Replacement of the damaged water pipe lines 50 mm dia. at MBPP to DC plant, NML.
13. Providing waterproofing treatment to new building of cost and programming wing, NML.

WORK IN PROGRESS

1. Painting and white washing of double-storyed FGH type quarters at Tuiladungri Colony.
2. Repair and replacement of broken ACC sheets and general maintenance work in sub-stores at FPTD, NML.
3. Painting and white washing of old A/10 type Flats at Agrico, NML.
4. Painting of the residential quarters at Tuiladungri Colony, FPTD and NML premises.

RESEARCH PLANNING

1. PROJECT MONITORING & EVALUATION—ANNUAL PLAN 1984-85

The Annual Plan for 1984-85, which includes revised estimates for 1983-84 and Budget Estimates for 1984-85 was drawn on the basis of requirements under on-going and new research projects; international collaborative projects; SAIL/NML collaborative programmes (MAPs), infrastructural needs and augmentation/ modernization of existing facilities where major thrust is proposed.

Projectwise planning and programming of research and development activities was continued, based on the thrust proposed during Sixth Five-Year Plan proposals.

The task forces on various SAIL/CSIR collaborative projects met periodically which helped in close monitoring of the projects (total 10 projects) for their scheduled completion.

2. WORKSHOP ON R&D PROJECT MANAGEMENT

A Workshop on R&D Project Management was organised at NML by the Centre for Management Development (NISTADS) in collaboration with NML during 28th November '83 to 2nd December '83. About 40 senior and junior Scientists of the laboratory along with the Heads of Administrative sections participated in the Workshop.

The Workshop dealt with varied aspects of R&D management, right from project selection, technology transfer, leadership styles and motivation etc. The Workshop generated highly fruitful discussions on R&D management.

3. RESEARCH APPRAISAL ACTIVITIES

During this period, two meetings of the Research Advisory Council were held, one in August '83 and the other in March '84 under the Chairmanship of Prof. R. V. Tamhankar. Evaluation of on-going projects and new proposals were made. Based on the recommendations of the RAC, necessary follow-up actions were taken.

4. SEVENTH PLAN PROPOSALS 1985-86 TO 1989-90

Final Seventh Plan proposals of the laboratory were formulated as per the guidelines set by the CSIR. The Seventh Plan Projections were divided into on-going and new activities. While selecting the R&D programme for the Seventh Plan period due weightage was given to technology policy statement, 20 point programme and capability/expertise developed at the laboratory over the years.

The thrust areas proposed were as follows:

1. Mineral beneficiation.
2. Pyro-metallurgy of non-ferrous metals.
3. Ferro-alloys.
4. High temperature metals and alloys for thermal power plants and petro-chemical industries.
5. Aluminium alloy development.
6. Physical metallurgy of steels and ferrous alloys.
7. Fracture mechanics.
8. Failure analysis and metallurgical condition monitoring in thermal power plants and metallurgical industries.

RURAL DEVELOPMENT

Active work in connection with the rural development programme for the CSIR Field Station at Bankura was continued to be undertaken. Work on the identified projects for NML viz. modification of rural melting and casting techniques, improvement in Dokra casting and preliminary work in the development of technology for producing fishing hook comparable to imported quality, is in progress.

NML scientists and staff actively participated in the get-together and exhibition arranged by NISTADS at Bankura from 23rd to 28th December, 1983 on 'Choice/adaptation/generation/transfer of technologies for rural development'. A theme paper on "The development of rural technologies for metallurgical based industries in general and for the district of Bankura in particular" was presented and was well received and appreciated.

In the above exhibition, 'chula' (furnace) for melting of bell and brass metal developed and designed at NML was exhibited. Other exhibits included tumblers, glass, tools, dokra castings etc.

PATENTS

The following patents were filed:

	Title	*Inventors*
1.	Improved process for casting of aluminium alloys to obtain fine grain refining thereof.	Rajendra Kumar C. S. Sivaramakrishnan R. K. Mahanti
2.	Process for liquid state treatment of aluminium or aluminium alloys.	Rajendra Kumar C. S. Sivaramakrishnan N. K. Das R. K. Mahanti
3.	Aluminium base galvanic anode to cathodically protect steel structures from sea water corrosion.	A. N. Mukherjee K. P. Mukherjee V. A. Altekar
4.	A process for the preparation and use of an inhibitor suitable for batch and continuous pickling of steels in sulphuric acid solutions at high temperature.	V. A. Atteker Inder Singh D. D. N. Singh M. K. Banerjee
5.	A process for preparation of a non-corrosive flux for soft soldering of copper and copper base alloys.	Inder Singh D. D. N. Singh M. K. Banerjee

TECHNICAL CONFERENCE

SEMINAR ON PROBLEMS & PROSPECTS OF FERRO-ALLOY INDUSTRY IN INDIA

A Seminar on Problems and Prospects of Ferro-Alloy Industry in India was organised jointly by the NML and the Iron & Steel Division of the IIM from 24th October to 26th October, 1983 at the National Metallurgical Laboratory, Jamshedpur.

The Seminar was attended by nearly 150 delegates from India and abroad, representing ferro-alloy industry, steel plants R&D organisations, academic institutions, representatives of government organisations and some well-known consulting engineering firms.

Prof. V. A. Altekar, Director, National Metallurgical Laboratory and Chairman, Organising Committee, welcomed the delegates. In his speech he touched upon the importance of the Seminar and the difficulties through which the ferro-alloy industry is passing and expressed the hope that the Seminar will consider and bring out the solutions to these problems.

The Seminar was inaugurated by the Union Minister of Steel & Mines, Shri N. K. P. Salve. Shri Salve described the progress of the ferro-alloy industry in the past twenty-five years and stressed upon improvement necessary for the healthy growth of this industry.

Shri R. H. Mody, Chairman, Tata Steel, presided over the function.

Dr. J. J. Irani, Dy. Managing Director, Tata Steel & Chairman of the Iron & Steel Division of IIM in his opening remarks elaborated on the status of ferro-alloy industry in the country and made special comments for its improvement.

Shri S. Samarapungavan, Chairman, SAIL, in his address made a plea to the ferro-alloy producers to interact and collaborate with research organisations, academic institutions and professional bodies like Indian Institute of Metals.

Dr. M. N. Dastur, Chairman & Managing Director of M. N. Dastur & Company Pvt. Ltd. in his special address traced the growth of ferro-alloy industry in the past and its prospects in future with respect to the present situation in the country particularly the high cost of production.

Dr. R. Kumar, Scientist (Director), NML proposed the vote of thanks.

The key-note and technical papers were then presented in six sessions covering the following areas:

Raw materials preparation, reductants, refractories, manufacturing processes, gas cleaning and pollution control, capacity utilisation, quality control and economics of production of various ferro-alloys.

On the concluding day i.e. 25th October, 1983 a panel discussion was held with the various Chairmen of the technical sessions and some experts under the Chairmanship of Prof. V. A. Altekar.

During this panel discussion, various problems which the ferro-alloy industry is facing came up and several remedies were suggested. The following recommendations of the panel were moved for taking necessary steps by the ferro-alloy products and authorities concerned for healthier growth of the ferro-alloy industry in India.

DISSEMINATION OF INFORMATION

NML Technical Journal

The research carried out by the Scientists at NML in various fields are brought out and published in the house journal. The NML Technical Journal Vol. 25 issue 1 to 4 of 1983 was edited and published.

Documented Survey on Metallurgical Development

Monthly abstracting service of NML on leading metallurgical articles drawn from over 600 journals received currently in the library. The Vol. No. 15 of the year 1983 was published.

Monograph on Indian Ores & Minerals

Vol. 2 of the Monograph covering beneficiation studies conducted on large number of Indian non-ferrous, strategic non-metallic ore & minerals, coal etc. has been edited and published.

Annual Report

Annual Report for 1982-83 was prepared and published.

NML Newsletter

The issue of NML Newsletter was brought out and published.

News Paper clipping service

Daily news paper including commercial and business papers were scanned and items of industrial and R&D importance, Governmental industrial policies, scientific and industrial inventions etc. were classified and departmentally circulated.

NML Brochure

A new colourful and illustrated brochure of the R&D activities of the Laboratory was prepared and is under publication.

Visit of Foreign Scientists under Science & Technology Programmes

The following foreign Scientists visited the Laboratory and held discussions with NML Scientists on the various aspects of R&D in their related fields of exchange programme.

1. Dr. A. L. Navaroo
   Institute Mexicano De Innestigociones Sidercergicas
   Saltilco, Mexico
2. Mr. J. A. Solis
   Institute Mexicano De Investigaciones
   Sidercergicas
   Saltilco, Mexico

Library Services

The Library added 907 new books. In addition to this nearly 103 publications, 180 periodicals were received on exchange and complimentary basis.

Under the 'Overseas Development Administration's Book Presentation Programme of British Council, 98 British books were received in two batches. The last batch of books under this programme is yet to be received.

The 'Current Awareness Service' was continued as a weekly service. This service covers principal content of journals on metallurgy and allied disciplines received in the Library within a week. Six select bibliographies on specific subjects were prepared for the scientists of the NML.

Besides, one special bibliography on 'Ferro-Alloy Production and its Application' (1970-82) was prepared on the occasion of a seminar on 'Problems and Prospects of Ferro-Alloy Industry in India', October 24-26, 1983 held at NML. This was published as a priced publication.

The scheme for 'Institutional Membership of NML Library for academic institution and R&D Units of industries continued to be in operation. During the period under review one more private organisation has become member.

PHOTOGRAPHY & PRINTING SERVICES

A. Photography

1. Audio-visual work on different R&D expertise on NML has been undertaken.

2. Photographic help to the research efforts of scientists involved in the polymetallic Sea Nodules has been extended.

3. Regular photographic and reprographic services continued to be rendered, besides preparation of exhibits such as translites, blow-ups etc. for publicity in exhibitions.

B. Printing, Services & Binding

Various types of printing jobs were undertaken during the period. Such work ranged from printing of forms, brochures, folders related to R&D activities of the laboratory to NML Newsletter, publicity, display materials etc. Printing jobs pertaining to Seminars, get-togethers were also undertaken. A large number of reports were also bound.

Exhibitions/Fairs

NML participated in the 'Indian International Trade Fair-1983' as a CSIR constituent laboratory which was held at Pragati Maidan New Delhi; from Nov. 14-27, 1983. The NML had displayed its know-how/ expertise in an elaborate way for the benefit of the interested entrepreneurs and general public.

HONOURS AND AWARDS

Shri G. N. Rao, Scientist, has been awarded Ph.D. degree of Ranchi University for his thesis on "Effect of Industrial Gases on Fundamental Properties of Indian Bentonites".

Shri S. Prabhakar, Scientist, has been awarded Ph.D. degree in Chemistry by Sri Venketaswara University for his thesis on "Studies on collecting Properties of Chelating Agents in Mineral flotation—Chalcopyrite-oxime and chalcopyrite cupferrous system".

DEPUTATION AND TRAINING

Dr. R. Kumar Scientist in the Grade of Director	Visited Hungary under the Indo-Hungarian Science and Technology Exchange Programme for a period of three weeks in November, 1983.
Dr. M. R. K. Rao Scientist	(*i*) Visited Mexico under UNIDO assignment as Refractories Expert on November, 1983. (*ii*) Underwent training on STA-409 simultaneous TG-DTA apparatus in West Germany on April, 1983.
Shri K. P. Mukherjee Scientist	Visited Japan to attend ASCA Seminar on "Corrosion Prevention of Metals" under the auspices of Science and Technology Agency, Govt. of Japan.
Shri S. C. Moulik Scientist	Attended a Six-week training programme in computer in Indian Statistical Institute, Calcutta.
Shri H. Patnaik Scientist	Attended a short term computer course at IIT, Kanpur.
Shri S. N. Prasad	Attended a short term course on 'Froth Flotation' at ICC, Ghatshila.
Shri S. K. Sengupta	-do-
Shri S. K. Sil	-do-
Shri U. S. Chatterjee	-do-
Shri L. N. Das Scientist	Attended a one-week course on "Transducers" held at Electrical Measuring Instruments, Bombay.
Shri S. K. Sinha	Attended a short term course on "Quality Assurance in Sand Casting" at IIT, Kharagpur.

CHAIRMANSHIP MEMBERSHIP ETC. OF NML STAFF ON OUTSIDE BODIES

Prof. V. A. Altekar Director	Fellow	Institution of Engineers (I).
	Member	Science Advisory Committee, Dept. of Steel. Ministry of Steel & Mines, Govt. of India.
Dr. R. Kumar Scientist in the Grade of Director	Member	Working Group on Power for the formulation of 7th Five-Year Plan, constituted by the Planning Commission (Power & Energy Division) as CSIR nominee.
	Member	International Editorial Advisory Board of the High Temperature Tech. Journal, U.K.
	Chairman	SMDC 10 of ISI.
	Member	IIM, Editorial Advisory Board.
	Member	Board of Governors, NIFFT.
	Member	Central Boiler Board.
	Member	ARDB, Ministry of Defence.
	Member	Advisory Board on the Material Sciences of Nuclear Sciences Committee of Atomic Energy Commission.
	CSIR Area Reviewer	For Metallurgy for the 7th Five-Year Plan Prospects.
Dr. M. R. K. Rao Scientist	Co-Chairman	Indian Ceramic Society, Jamshedpur Chapter.
Shri M. J. Shahani Scientist	Member	Editorial Board, Powder Metallurgy Association of India.

APPENDIX I

Paper Published, Communicated and Presented

1. Beneficiation of some copper ores at NML for Hindustan Copper Limited—By M/s. M. V. Ranganathan, J. P. Srivastav and N. Chakravorty.—Presented at the National Symposium on Mineral beneficiation at Khetrinagar held in April, 1983.

2. Potentials and availability of mineral raw materials for ferro-alloy production in India—by S. Mohana Rao, M. V. Ranganathan and A. Peravadhanulu—at the National Seminar on Problems and prospects of ferro-alloy industry in India at NML, Jamshedpur, on October, 1983.

3. Beneficiation studies on Molybdenite at the NML—by P. D. Prasad Rao, A. Peravadhanulu, D. M. Chakrabarti and N. Chakravorty at the 37th Annual Technical Meeting, Indian Institute of Metals, Banaras in 1983.

4. Characterisation and beneficiation studies on some Indian Ores—by A. Prevadhanulu, N. Chakravorty, A. K. Sinha Mahapatra and K. N. Gupta—All India Seminar on Extraction of Iron held at Bhilai in 1984.

5. Studies on reactivity of lime—by K. C. Roy, P. C. Sen and M. R. K. Rao. Trans. Ind. Cer. Soc., Vol. 42 (5), 1983.

6. Natural graphite a raw material for Refractories and other Industries—by P. C. Sen and M. R. K. Rao, Published in first Indian Carbon Conference, December, 1982.

7. A critical review of the utilization of Fly-ash and its mineralogical studies—by B. K. Mitra, A. Dasgupta, P. C. Sen and M. R. K. Rao, Presented at the Seminar on Utilisation of Fly-ash held in 1984 at Jamshedpur.

8. Developments in Ferro-alloy furnaces —by B. Chatterjee, M. C. Kundra, and M. R. K. Rao, National Seminar on the Problems of Ferro-alloy industry in India at NML in 1983.

9. Studies on the development of high temperature refractory castable suitable for 1500-1700°C—by M. C. Kundra, S. K. Malaviya and M. R. K. Rao—48 Annual Technical Session of Indian Ceramic Society at New Delhi in 1984.

10. Studies on liquid-phase sintering of MgO-Chinaclay Compacts—by K. K. Singh, V.A. Altekar and MD. Narasimhan, Tr. C S, Col. 42(6)

11. Thermodynamics and phase equilibria during smelting of vanadium bearing titani-ferrous magnetite ore and making vanadium rich slag—by A. K. Nayak, N. Subrahmanyam and D. D. Akerkar—Journal of Inst. of Engrs. (India) Vol. 64, July, 1983.

12. Extraction of base metals from complex sulphide ores. A review of roast, leach, solvent extraction and Electro-winning process—by D. D. Akerkar, M. G. Bodas, B. D. Pandey and R. K. Jana—Symposium on Advances in Electrometallurgy held at E.R.G.R.I., Karaikudi in April, 1983.

13. Metallothermic process of calcium metal production by reduction of lime with aluminium powder—Symposium on Metallothermic process in metal and alloy extraction held at Nagpur in 1983.

14. Recovery of copper and zinc by solvent extraction and Electro-winning from leach liquors obtained in the sulpation roast—leach processes for complex sulphide ores by R. K. Naja, B. D. Pandey, M. Yaseen, M. G. Bodas and D. D. Akerkar—37th Annual Meeting of IIM held at BHU, Varanasi in 1983.

15. Purification and enrichment of molybdenite concentrates by disilication and chloridizing roasting—by A. K. Saha, S. R. Srinivasan and D. D. Akerkar—37th Annual Technical Meeting of IIM held at BHU, Varanasi in 1983.

16. Standaridization of melting technology of Air Craft Grade Aluminium Alloys—by C. S. Sivaramakrishnan, B. K. Saxena and Rajendra Kumar—ISI Bulletin Vol. 36, No. 4, 1984.

17. "Non-polluting, non-corrosive treatment of aluminium melt"—by Rajendra Kumar, B. K. Saxena, Kishori Lal and A. K. Bhattamishra—Presented at 37th ATM of IIM, BHU, November. 1983.

18. "Al-5 p.c. Mg alloy extruded tube as support member of overhead electric traction—case study"—by G. G. Nair, A. K. Bhattamishra, Kishori Lal, B. K. Saxena and R. Kumar—Presented at 27th Annual Technical Meeting of IIM, BHU, November, 1983.

19. "Utilization of Ferro-manganese slag for production of manganese sulphate/electrolytic manganese metal/manganese dioxide"—by P. L. Sengupta and N. Dhananjayan—Presented at the National Seminar on "Problems and Prospects of Ferro-alloy Industry in India" held at NML, October, 1983.

20. "Titanium anodes in electrolytic Manganese dioxide manufacture"—by P. L. Sengupta, N. Dhananjayan and V. A. Altekar—Presented at the Seminar on "Titanium for aerospace, chemical and other applications" held at Trivandrum, December, 1983.

21. "Pilot Plant Test Data on the manganese ore sample supplied by Electro-Chem. (Orissa) Ltd., for production of electrolytic manganese dioxide"—by P. L. Sengupta and N. Dhananjayan—Sponsored Investigation Report, NML, April, 1984.

22. "Studies on Mn-Al-C permanent magnet alloys"—Presented at the Annual Technical Meeting of IIM, at Banaras, November, 1983.

23. On the phase-formation in Mn-Al-C alloys at the National Seminar on Magnetics held at Bangalore on 28-29 November, 1983.

24 Effect of Mn on the magnetic properties of Co-14 p.c. Al alloys—Ved Prakash and C. R. Tewari—Trans. IIM, Vol. 37, No. 1, 1984.

25. Tube Failure in Thermal Power Plants—R. Singh and R. Kumar—Presented at the Seminar on Tube Failure sponsored by Institution of Engineers, Jamshedpur Sub-Centre, July, 1983.

26. Welding and Weld Inspection in thermal power plants—R. Singh, G. G. Nair and R. Kumar —Published in Proceedings of Annual Weld Meet., NML Jamshedpur, 17th August, 1983.

27. Failure of Weld Joints in Thermal Power Plant—R. Singh and R. Kumar—Presented at 37th Annual Tech. Meet. of IIM, BHU, 1983.

28. Tertiary Creep in $2\frac{1}{4}$ Cr-IMo Steel—R. N. Ghosh, R. Singh and R. Kumar—Presented at 37th Annual Technical Meeting of the IIM, BHU, 1983.

29. Application of Cr-Mn-N.C. Austenitic steel for Exhaust Valves—K. Prasad, R. Singh and R. Kumar—Presented at the National Seminar on Materials in Automobile Industries, NML, Jamshedpur, 1983.

30. Analytical Techniques and sophisticated instrumentation in metallurgical research—L. N. Das—Presented at the National Conference on Instrumentation held at CSIO, Chandigarh, 1983.

31. Computer System in the automation of a large high temperature material testing facility and analytical laboratory—L. N. Das—Presented at the World Instrumentation Symposium, New Delhi, January, 1984.

32. Development of Testing Fixture to Continuously Monitor the Stress—Corrosion Cracking Behaviour—Gurdev Jaura—Presented at the National Conference on Instrumentation held at CSIO, Chandigarh, 1983.

33. Problems Being Faced by the Instrumentation Personnel, Seeking Higher Knowledge—Some Suggestions—Gurdev Jaura—Presented at the International Symposium on Instrumentation organised by the Institution of Instrumentation Scientist and Technologists (India) at Park Hotel, Calcutta, 1983.

34. Heat resistance properties and structure of Aluminium cast iron—C. A. N. Rao, S. S. Dhanjal, G. N. Rao and V. A. Altekar—Presented at the Seminar on "Recent Trends in Foundry Technology", IIF, Jamshedpur, 3rd & 4th September, 1983.

35. Requirements of Quality standards for dimensional accuracy and surface finish—S. K. Sinha, T. A. Beck and G. N. Rao—Presented at the Seminar by IIF, Ranchi, 18th & 19th June, 1983.

36. Chilling in Hypoeutectic cast iron—S. K. Sinha, M. Ram and G. N. Rao—Presented at the 33rd Annual Convention of the IIF New Delhi, 19-21 March, 1984.

37. Metal Foam and its applications—S. K. Sinha and G N. Rao—Presented at the Seminar on "Recent Trends in Foundry Technology, IIF, Jamshedpur, 3rd & 4th September, 1983.

38. Statistical evaluation of indigenous foundry moulding sands from Northern Region—R. R. Das, S. K. Sinhababu and G. N. Rao—Presented at 33rd Annual Convention of IIF at New Delhi, 19-21 March, 1984.

39. Statistical evaluation of natural foundry moulding sands of West Bengal—R. R. Dash, S. K. Sinhababu and G. N. Rao—Presented at the I.I.F. Seminar, Calcutta, September, 1983.

40. When and how to choose ferro-alloys for cast iron foundry—R. R. Dash and G. N. Rao—Presented at the National Seminar on Problems & Prospects of Ferro-alloy Industry in India held at NML, Jamshedpur, 24-26th October, 1983.

41. Production of calcium silicide—Methods of Production and their technological consideration—D. D. Akerkar, A. K. Vaish, S. S. Dhanjal and G. N. Rao—Presented at the National Seminar on Problems & Prospects of Ferro-alloy Industry in India, held at NML, Jamshedpur, 24-26th October, 1983.

42. High Chromium Cast Iron—R. K. Dubey, T. A. Beck—Published in The Indian & Eastern Engineer, Vol. 125, No. 7, July, 1983, pp. 323-328.

43. When to choose Rotary furnace for Iron melting. (IR220/83)—S. Ghosh and G. N. Rao—Paper communicated for presentation at Seminar on Foundry Industry organised by SSI, Delhi, 1983.

44. Roll cladding of copper on aluminium and development of a continuous annealing schedules—by J. Bhattacharya, B. N. Ghose and S. K. Banerjee, Sheet Metal Industries, U.K., Vol. 60, No. 5, May, 1983, p. 300.

45. Differential deformation during roll-bonding of dissimilar metals—by J. Bhattacharya, B. N. Ghose and S. K. Banerjee. Accepted for publication in the special issue of IIM Journal, 1984.

46. Development of silver-nickel contact materials by P/M Technique—by V. A. Altekar, R. K. Dubey, S. K. Chaudhury, S. P. Chakraborty and P. K. De—Published in Transactions of the PMAI, Vol. 10, 1983.

47. Corrosion problems and combating research activities in India. RR 424/84—K. P. Mukherjee—Presented at the 4th ASCA Seminar at Tokyo, March, 1984.

48. Development of high output aluminium anode for cathodic protection—Shri A. N. Mukherjee, K. P. Mukherjee and V. A. Altekar—Presented at the A.T.M. of IIM, November, 1983.

49. Silver tarnishing and its prevention—A review—Inder Singh, Miss. P. Sakita and V. A. Altekar. Anti-Corrosion Methods and Materials, Vol. 30 (7), July, 1983.

50. Hydrogen Absorption in sulphuric acid containing polar organic compounds—Inder Singh and V. A. Altekar—Material Research Society, USA.

51. Corrosion and passivation behaviour of Ti-6Al-4V alloy in phosphoric acid solution. Method—Accepted for publication in J. Elect. Chem. Soc. (USA).

52. Vapour phase Inhibitors; A review—D. D. N. Singh and M. K. Banerjee. Anti-Corrosion methods and materials.

53. Inhibition and corrosion behaviour of Ti-6Al-4V Alloy in hydrochloric and phosphoric acid solutions—D. D. N. Singh, M. K. Banerjee and P. S. Nag—NML Tech. Jr. 3, 1982, 31.

54. Role of National Metallurgical Laboratory in the development of zinc rich primers—P. Prabhakaram, A. K. Dey, A. N. Mukherji and V. A. Altekar—Proceedings of National Conference on zinc rich coatings for corrosion protection, New Delhi, 28th & 29th November, 1983.

55. Performance evaluation of zinc rich primer based on soluble silicates—P. Prabhakaram, A. K. Dey, S. Rao Addanki and D. K. Khan (Under publication in NML Tech. J.).

56. Permanent black finishes on Aluminium—T. L. Sharma, Y. N. Trehan and S. K. Narang—J. Electrochemical Society of India, Vol. 32, No. 3, 268 (1983).

57. Development of Integral colours of aluminium and its alloys—T. L. Sharma and Y. N. Trehan—J. Electrochemical Society of India, Vol. 32, No. 4, 389 (1983).

58. Sliver Plating from non-cyanide baths—S. K. Narang—Presented at ATM of ECSI, Bangalore, July 20, 1983.

59. The successive determination of aluminium and titanium in ferro-titanium by complexometric titration—B. C. Bose, V. N. Choudhury and L. P. Pandey—J. Metals & Minerals Rivew 1983, 22, 108.

60. Anti-pyrylazo III and thymolphthalexon as indicators for the complexometric determination of calcium and magnesium in lime stones—B. C. Mukherjee, N. N. Ganguly, V. N. Choudhury and L. P. Pandey—Ind. Ceram. 1983, 26, 44.

61. Pyrrole-2-thiocarboxamide as a new gravimetric reagent for nickel—L. P. Pandey and A. C. Basak—Jour. Inst. Chemists (India) (in press).

62. Stability of metallic alloys in liquid phase—C. S. Sivaramakrishnan and R. Kumar—Presented at the Seminar on Phase Stability and Phase Transformation at BARC, Bombay, February 6-8, 1984.

63. Solidification and grain refinement of Al alloys—Presented at Seminar on Solidification of metals—Future trends at RRL, Bhopal, April 25-26, 1984.

64. Morphology of fracture in Al and Mg alloys—A study through SEM—N. K. Das, C. S. Sivaramakrishnan, R. K. Mahanti and R. Kumar—Presented at 37th Annual Technical Meeting of IIM at BHU, November 16-17, 1983.

65. Morphology of fracture in Al and Mg alloys—C. S. Sivaramakrishnan, N. K. Das, R. K. Mahanti and R. Kumar—Accepted by Aluminium (GMbH Germany) for publication. 1984, 60, E 467-471.

66. Radio Isotope as a Tool in Metallurgical Research—by Aruna Bahadur—Paper submitted to Trans. Indian Institute of Metals for publication.

67. Zeta potential and absorption studies of chalcopyrite—DTC system—V. Mangalam and P. R. Khangaonkar—Paper accepted for publication in International Journal of Mineral Processing.

APPENDIX II

Research & Investigations completed and Report prepared **1983-84**

Research Reports

1. High resistance properties and structure of aluminium alloyed cast iron—G. N. Rao, S. S. Dhanjal, C. A. N. Rao and V. A. Altekar (RR 412/83).

2. Corrosion behaviour of high strength, medium conductivity NML—PM 215, aluminium alloy conductor—A. K. Bhattamisra, Kishorilal and R. Kumar (RR 413/83).

3. Pilot plant trial of roast-reduction-ammonia—ammonium carbonate leaching of Sukinda nickel laterite ores from Kansa in vertical reduction furnace—D. D. Akerkar, Z. H. Khan, M. S. Mohanty, B. N. Singh, B. V. S. Yedavalli and S. K. Singh (RR 414/83).

4. Measurement of Specific surface (Permeability method)—Joga Singh (RR 415/83).

5. Statistical evaluation of natural foundry moulding sands from West Bengal—R. R. Das, S. K. Sinha and G. N. Rao (RR 416/83).

6. Significance of non-conventional testing methods for foundry moulding sands—S. Ghose and G. N. Rao (RR 417/83).

7. Recovery of Vanadium Pentoxide from Vanadium bearing slag by an alkaline roast-leach process—D. Bagchi, A. K. Nayak and D. D. Akerkar (RR 418/83).

8. Some observations on the Aluminium—Magnesium coinage alloy—R. Kumar, C. S. Sivaramakrishnan, R. K. Mohanti and A. K. Bhattamisra (RR 419/83).

Investigation Reports

1. Evaluation of physical and refractory properties of Fire clays—B. K. Mitra, P. C. Sen and M. R. K. Rao (IR 1138/83).

2. Determination of work index and crushing strength of an ore sample from M/s. UCIL, Jadugoda (IR 1139/83).

3. Report on the beneficiation of Gua iron ore and its slime together with Kiriburu slime prepared for M/s. Mineral Development Board, New Delhi—U. S. Chatterjee, R. K. Kunwar, J. S. Padan and N. Chakraborty (IR 1140/83).

4. Pressure leaching of Chitradurga Copper concentrates with Sulphuric Acid—P. V. Viswanathan, C. Sankaran and P. R. Khangaonkar (IR 1141/83).

5. Creep test results on Copper, Copper Alloy and Aluminium Alloy (IR 1142/83).

6. Investigational report of the failure of the water wall tube supplied by IOC Haldia—S. Choudhury, R. Singh and R. Kumar (IR 1143/83).

7. Assessment of Residual life of main steamline pipe in the Thermal Power Station of Neyveli Lignite Corporation—R. Singh, R. K. Sinha, Y. N. Tewari and R. Kumar (IR 1144/83).

8. Studies on Iron ore samples from SAIL—A. Raja Kumar, K. Vijayaraghavan and P. R. Khangaonkar (IR 1145/83).

9. Determination of Specific physical characteristics of Limestone and Dolomite samples received from M/s. Visakhapatnam Steel Project (Rastriya Ispat Nigam Ltd.)—S. K. Sengupta, S. Mohan Rao, M. V. Ranganathan, A. Peravadhanulu and D. M. Chakravarty (IR 1146/83).

10. Determination of work Index of Blue dust sample received from M/s. A.S.C. Engineers and Allied Industries, Calcutta—S. K. Sil, M. V. Ranganathan and N. Chakravorty (IR 1147/83).

11. Stress relaxation test, Tensile test, Bend test, susceptibility to stress corrosion on 4 mm p.c. wire sponsored by I.S. Trivendrum, Kerala—R. Kumar, K. Prasad, T. R. Soni and R. Singh (IR 1148/83).

12. Specified physical tests and determination of free silica content in a raw magnesite sample for M/s. Mcnally Bharat Engineering Co,. Kumardhubi—S. K. Sil, S. Mohan Rao, B. Banerjee, M. V. Ranganathan, A. Peravadhanulu and D. M. Chakravarty (IR 1149/83).

13. Physical, Chemical, Mineralogical and calcination studies on a limestone sample from M/s. Kudermukh Iron Ore Co. Ltd. (KOICL)—A. Rajkumar, K. Vijayaraghavan, P. V. Viswanathan, V. Mohan, C. Satyanarayan, C. Sankaran and P. R. Khangaonkar (IR 1150/83).

14. Washability studies with coal sample from Jagannath Colliery for production of concentrates for Ash silica studies for CMPDI—S. K. Sengupta, P. D. Prasad Rao, D. M. Chakravarty and N. Chakravarty (IR 1151/83).

15. Development and testing of creep resistant steels from M/s. BHEL Ltd., Hyderabad—R. Kumar, R. Singh, R. N. Ghosh, K. Prasad, S. Choudhury, T. R. Soni, R. K. Sinha and Y. N. Tiwary (IR 1152/83).

16. Bench scale floatation studies on a sample of coal middlings from Kedla Mines, Seam No. V for M/s. CMPDI, Ranchi (IR 1153/83).

17. Assessment of residual life of second stage super heater tube of Unit No. V (50 MW) of Barauni Thermal Power Station, Begusarai, Bihar State Electricity Board (IR 1154/83).

18. Investigation report on the failure of Part I—Primary super heater tube, Part II—Secondary super heater tube, Part III—Repeater outlet rendent tubes of unit No. 1, (120 MW) supplied by Korba Thermal Power Station (MPES) (IR 1155/83).

19. Characteristics of imported Aluminium alloy Boomerang grab (for collection of Polymetallic nodules from seabed) for material specification by NIO (GOA)—R. Kumar, Kishorilal, Inder Singh and A. K. Bhattamisra (IR 1156/83).

20. Washing of clay samples from BHEL, Bangalore—A. Rajkumar, V. Mohan and P. R. Khangaonkar (IR 1157/83).

21. Determination of Bord's work index of two gold tailing dump samples from Bharat Gold Mines Ltd. KGF—K. Vijaya Raghavan and P. R. Khangaonkar (IR 1158/83).

22. Exploratory studies on beneficiation of Ferruginous Manganese Ores using solid reductants Part I—J. P. Srivastava, S. Rafiuddin and N. Chakravorty (IR 1159/83).

23. Bench scale beneficiation studies of kyanite samples received from M/s. Maharashtra State Mining Corporation Ltd., Nagpur. Part I—Dadhala Mrigton & Mines—T. C. De, S. Sivaiah, S. K. Sengupta and N. Chakravorty (IR 1160/83).

24. Beneficiation of low grade kyanite samples from Maharastra State Mining Corporation—Part II—Jamgaion & Borgaon Mines—T. C. De, S. K. Sil and N. Chakravorty (IR 1161/83).

25. Reduction of ash contents by froth flotation from the middlings of Kedla Seam IV received from CMPDI, Ranchi—S. Sivaiah, P. D. Prasad Rao, D. M. Chakravorty and N. Chakravorty (IR 1162/83).